INSTRUMENTATION
File Reference.

G4

MODEL 132L
PULSE GENERATOR

E-H RESEARCH LABORATORIES, INC.
163 ADELINE STREET · OAKLAND 20, CALIFORNIA

MODEL 132L
PULSE GENERATOR

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EH RESEARCH LABORATORIES, INC.

163 ADELINE STREET • TEmplebar 4-3030 • OAKLAND 20, CALIFORNIA

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S/N. 137[illegible]

SPECIFICATIONS

The E-H 132L Pulse Generator is designed to provide fast rise time, high current pulses over a wide range of pulse widths and repetition rates. It has provision for double pulse and single shot functioning, provides a fast negative going trigger pulse and may be externally gated.

REPETITION RATE—10 cycles per second to 3.5 megacycles as a single pulse generator, 10 cycles per second to 1 megacycle in double pulse mode. Frequency internally generated and selectable by front panel step and vernier controls. The instrument may also be operated as a single shot generator, fired by a panel mounted push-button switch, or externally driven from zero to 3.5 megacycles by a negative 4-volt pulse.

RISE TIME — Typically 10 nanoseconds and always less than 12 nanoseconds, variable to more than 100 nanoseconds.

FALL TIME — Typically 10 nanoseconds and always less than 15 nanoseconds.

PULSE OUTPUT — 50 volts maximum into 50 ohms.

PULSE WIDTH — Less than 100 nanoseconds to more than 10 milliseconds continuously variable by step and vernier controls.

PULSE DELAY — Less than 100 nanoseconds to more than 10 milliseconds continuously variable by step and vernier controls.

POLARITY — Positive or negative pulses selected on the front panel.

DUTY FACTOR — 25 per cent at full amplitude; an automatic limiter prevents average currents in excess of 250 milliamps.

OUTPUT ATTENUATOR — Up to 150:1, coarse selector and continuous vernier control.

JITTER — less than 0.1 per cent.

TRIGGER OUTPUT — For sync purposes, a 2-volt negative pulse approximately 30 nanoseconds wide is provided from a source of 330 ohms impedance.

EXTERNAL DRIVE — A 4-volt negative input is required to drive the Model 132L externally.

ELECTRONIC GATE — 5 volts negative connected to the gate input will interrupt the pulse train for the duration of its presence. Input impedance is 2.4 kΩ shunted by 100 pF.

DOUBLE PULSE

In the double pulse mode a pre pulse similar in amplitude and shape to the main pulse is generated at approximately 20 nanoseconds after the leading edge of the trigger pulse. The time period between the start of the pre pulse to the start of the main pulse is controlled by the DELAY controls. The main pulse shape will deteriorate if the second pulse starts less than 300 nanoseconds after the first pulse or if the time between pulses is less than the pulse width. Double pulse facilities are limited to maximum P.R.F. of 1 megacycle.

DIMENSIONS

Rack Mounted: 7″ high, 19″ wide, 16″ deep.
Weight: 22 lbs. net; 30 lbs. packed.

ACCESSORIES

Are available, please contact your local distributor.

The coarse DELAY selector and the FINE vernier provide continuous control over the relative position of the trigger output and pulse output. The single pulse output can be delayed from 0.1 microsecond to 10 milliseconds with respect to trigger output. On double pulse the delay is with respect to the leading edge of the first pulse.

The amplitude of the output pulse is continuously variable over an approximate 3:1 range by the AMPLITUDE control.

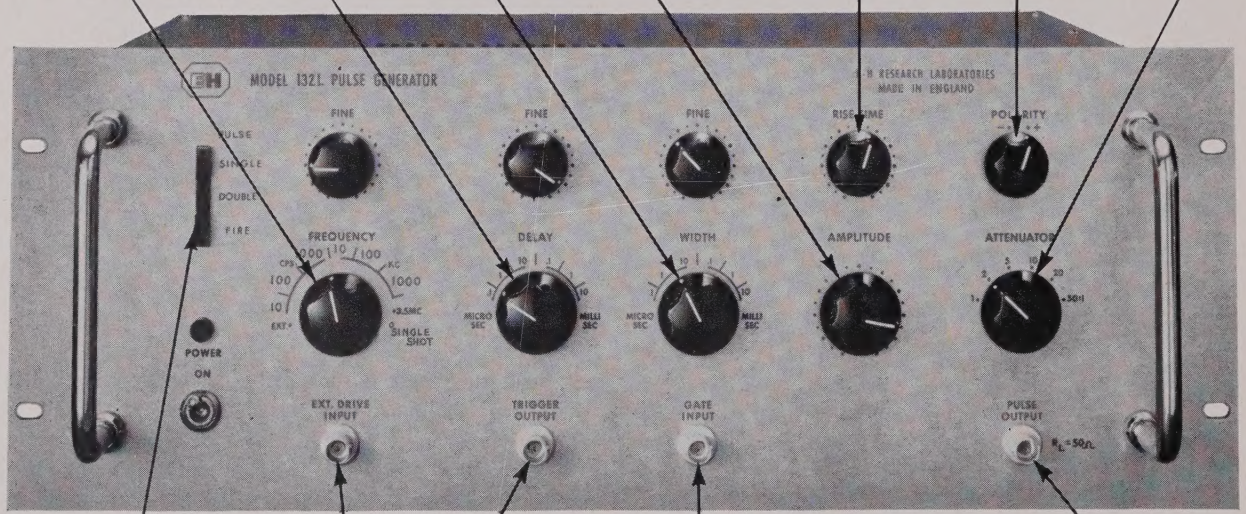
The POLARITY switch selects either positive or negative output pulses.

The internal rep. rate is controlled by a coarse FREQ. RANGE selector, which is calibrated in decade steps. The FINE control provides continuous coverage within the selected decade range.

The coarse WIDTH selector switch and FINE control vary the width of output pulses from .1 microsecond to 10 milliseconds.

The RISE TIME control varies the leading edge rise time from 10 to 100 nanoseconds.

The six step ATTENUATOR provides attenuation ratios from 1:1 to 50:1.



To drive the instrument externally, FREQ. RANGE selector must be set to EXT. and 4-volt negative input applied to the EXT. DRIVE INPUT connector.

A negative 5-volt signal applied to the GATE INPUT will interrupt the pulse train as long as the signal remains.

The pulse train is taken from the PULSE OUTPUT connector. The output is designed to operate into a 50-ohm, resistive load.

The push buttons select either single or double pulse function, the " FIRE " button initiates one pulse train when the frequency switch is at " Single Shot ".

The trigger output is a negative 2 volt pulse.

OPERATING INFORMATION

117 VOLT OPERATION

The internal power supply of the 132L is normally wired for 234 volts. Simple rewiring of the primary permits operation at 117 volts. Refer to the schematic diagram at the back of this manual for the proper primary connection to provide operation at 117 volts.

CONTROLS

The operating controls, which are mounted on the front panel, and the instructions for their proper use are shown in the illustration on the opposite page.

OUTPUT IMPEDANCE

The Model 132L is a current source when the output pulse is negative and a voltage source when the output pulse is positive. Although the impedance at the output connector is not 50 ohms, the instrument is designed to operate into a 50-ohm resistive load. Operation into any other impedance will cause some pulse distortion. Loads with appreciable capacitive or inductive components will have a marked effect on the leading and falling edges of the pulse.

CAUTION

The instrument should always be operated with a load connected to the output.

DUTY CYCLE

The duty cycle limitation is to insure long life by conservative operation of the output tubes. The duty cycle is controlled electronically by monitoring the output current to maintain it at a maximum of 250 milliamps average. The effect is that as the duty cycle reaches 25 per cent, the amplitude of the output pulse is proportionately decreased as the duty cycle is increased.

NOTE

The minimum available pulse width and the duty cycle limitation prevent full output at 3.5 megacycles.

Typically, pulse widths of up to 80 per cent of the period can be obtained. Extending the pulse width past the normal period may cause the generator to scale down in frequency or unusual pulse distortion conditions to appear. However, no damage can occur to the instrument.

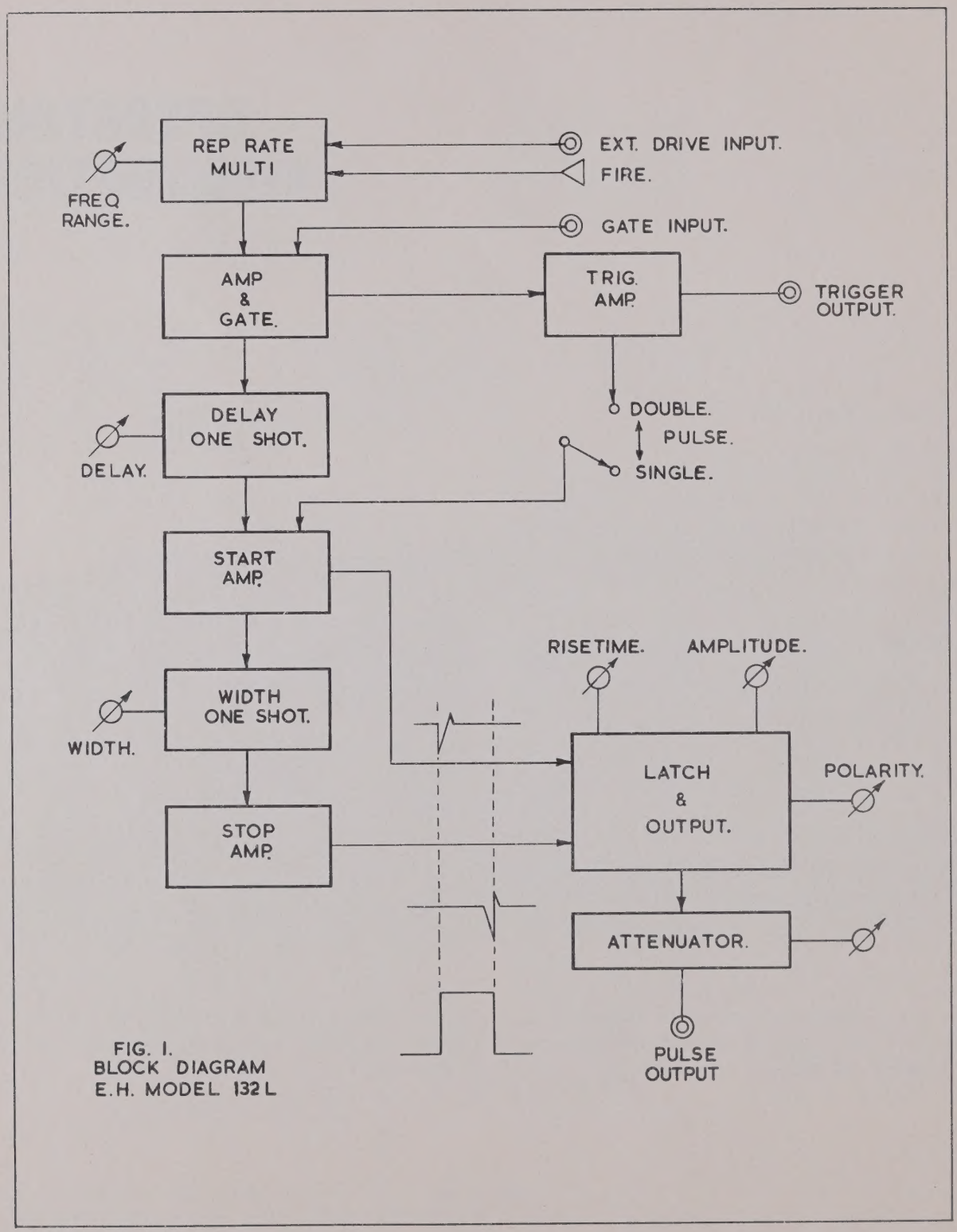


FIG. 1.
BLOCK DIAGRAM
E.H. MODEL 132 L

THEORY OF OPERATION

GENERAL DESCRIPTION

Refer to the block diagram on the opposite page. The basic timing cycle is initiated by an asymmetric multivibrator, which may be free-running or externally driven. The output from the repetition rate multivibrator is differentiated, amplified, and applied to a gate circuit which passes a signal to the delay one-shot multivibrator unless a voltage is applied to the gate input, which then blocks the pulse train. The output of the amplifier is also coupled to the trigger output amplifier.

The delay one-shot multivibrator determines the position of the output pulse with respect to the trigger. The signal from the delay one-shot is amplified and goes to the width one-shot multivibrator which determines the width of the output pulse. The signal from the delay amplifier is also applied to the start amplifier to initiate the start of the output pulse.

The output from the width one-shot amplifier is applied to the stop amplifier to initiate the stop of the output pulse. The start and stop amplifiers drive the latch. The latch is a quasi-stable circuit which is turned on by the start signal and remains in that state, providing a constant amplitude output level, until turned off by the stop signal.

REPETITION RATE MULTIVIBRATOR

Q1 and Q2 comprise a free-running multivibrator capable of running at very fast repetition rates. To understand the operation of this multivibrator, assume that the switching is as shown on the schematic and that the timing capacitor has charged up to some positive level. Q1 is consequently turned off and Q2 is forced into conduction by the negative bias obtained through R3, CR3, and R9. The timing capacitor on the base of Q1 will discharge through variable resistor R2 and-fixed resistor R8 to the negative voltage level at the base of Q2.

It is important to note that because Q2 is conducting, there is a voltage drop across R7 and, consequently, the emitter voltage of Q2 is less than the emitter voltage of-Q1. Thus, the timing capacitor on the base of Q1 will discharge to the voltage level at the base of Q2 until such time as the base emitter drop of Q1 becomes less than the base emitter drop of Q2. Q1 will then start to conduct; its collector voltage will start to go positive, which in turn will cause the base of Q2 to go positive, forcing it out of conduction.

The timing capacitor now takes on the charge due to the difference in potentials between the bases. As the capacitor charges, Q1 remains in conduction until the difference in potential between the bases is slightly less than the bias developed across R4. When this occurs, Q2 is forced back into conduction and Q1 becomes cut-off.

AMPLIFIER AND GATE

Q3 is an amplifier to drive the delay multivibrator. In a condition without the presence of a gate signal, Q3 is nonconducting. The differentiated pulse from the multivibrator is amplified by Q3 when a gating signal is not present.

The gate amplifier Q4 is connected with its emitter in parallel with Q3. Q4 also is cut-off as determined by the biases of the diodes. When a negative 5-volt gating signal is applied to the base of Q4, the common emitters of Q3 and Q4 are held several volts negative. Q3, then, cannot conduct and the pulse chain is interrupted for as long as the gating signal is applied. Note that the zener diode protects the base of Q4 from being driven too far negative by large amplitude gating signals.

TRIGGER OUTPUT

The amplifier output is capacitively coupled to Q5. The trigger output amplifier Q5 produces a sharp negative trigger spike, approximately 2 volts in amplitude, which is delivered to the front panel through a capacitor and a 330 ohm series isolating resistor.

DELAY MULTIVIBRATOR

The output of amplifier Q3 is applied directly to the delay multivibrator, comprised of Q6, Q7, and Q8. Q8 is a low impedance source for driving the timing capacitors, while Q6 and Q7 form a monostable multivibrator. In the stable condition Q7 is biased on —the bias being developed across the forward resistance of diode CR12. With Q7 on, Q6 is forced into nonconduction. The input of the multivibrator is the base of Q8. It is an emitter follower and whenever a positive

input pulse is received from the previous stage, it is coupled through Q8 and one of the timing capacitors to the base of Q7. Q7, which is normally conducting, is cut-off by the positive swing and Q6 is forced into conduction. As Q6 goes into conduction, its collector goes positive. The collector of Q6 is tied to the base of Q8 so the action becomes regenerative, and the multivibrator very rapidly switches to its quasi-stable state until the timing capacitor is discharged through variable resistor R26 and fixed resistors R25 and R27. Variable resistor R26 controls the discharge time and serves as the FINE DELAY control. The output of the delay multivibrator is a small positive pulse taken from the collector of Q7 by differentiating through C38. This pulse drives Q13, the start pulse amplifier.

WIDTH MULTIVIBRATOR

The operation of the width amplifier Q9 and the width multivibrator Q10, Q11 and Q12 is identical to the delay multivibrator, except that the drive pulse to start the width multivibrator is taken from the start amplifier Q13 through capacitor C40 to the base of Q9.

START AND STOP AMPLIFIERS

The start pulse amplifier Q13 is biased nonconducting by CR18. When the positive start pulse from the delay multivibrator arrives, it drives Q13 into conduction which provides a sharp current pulse through transformer T2. The operation of Q16 is identical except that it receives its pulse from the width multivibrator —therefore, initiating the stop pulse.

OUTPUT CIRCUITRY

The output pentode tube V1 is operated with approximately equal loads in the plate and cathode at all times. When the POLARITY switch is in the plus position, the attenuator presents its load to the cathode and R63-66 (a 40-ohm, 8-watt resistor) is in the plate circuit. When the POLARITY switch is in the negative position, the +175 volts is grounded and V_o becomes —175 volts; the 40 ohm resistance is switched to the cathode and the output is taken from the plate of V1.

The output circuitry will be described assuming the POLARITY switch is in the positive position. The output tube V1 and transistors Q14 and Q15 form a bi-stable latching-circuit, which when driven on will remain on until driven off. CR28 is a zener diode which holds the grid at —39 volts bias during the normally off condition so that no current flows in the output tube. The collector of transistor Q14 is also held at —39 volts. When the negative start pulse from T2 is received at the base of Q14, it turns that transistor fully on. As that transistor conducts, its collector rises. The grid of V1 also rises, turning on Q15. The cathode follows the grid producing the output pulse. Hold current to keep the transistor in saturation once it is turned on is provided through CR29, R84, R85, and R86. The —150 volt supply draws sufficient current through R85 and R86 from the base of Q14 to hold that transistor on.
Since the current through the zener diode also flows to the cathode and, therefore, through the load, resistors R57, R58 and R59 are inserted to bleed some positive current into the cathode load to offset this negative current so that there is no DC level shift. The stop pulse from Q16 is coupled through transformer T1 to the base of Q15. The collector of Q15 is coupled through diode CR26 to the grid of V1 so that when the stop pulse appears, the grid of V1 is again driven negative to its —39 volt turn-off bias. The third winding on T1 also provides a positive pulse through CR22 and CR23 to the base of Q14, which helps turn off this transistor at the time of the stop pulse.

DOUBLE PULSE FACILITY

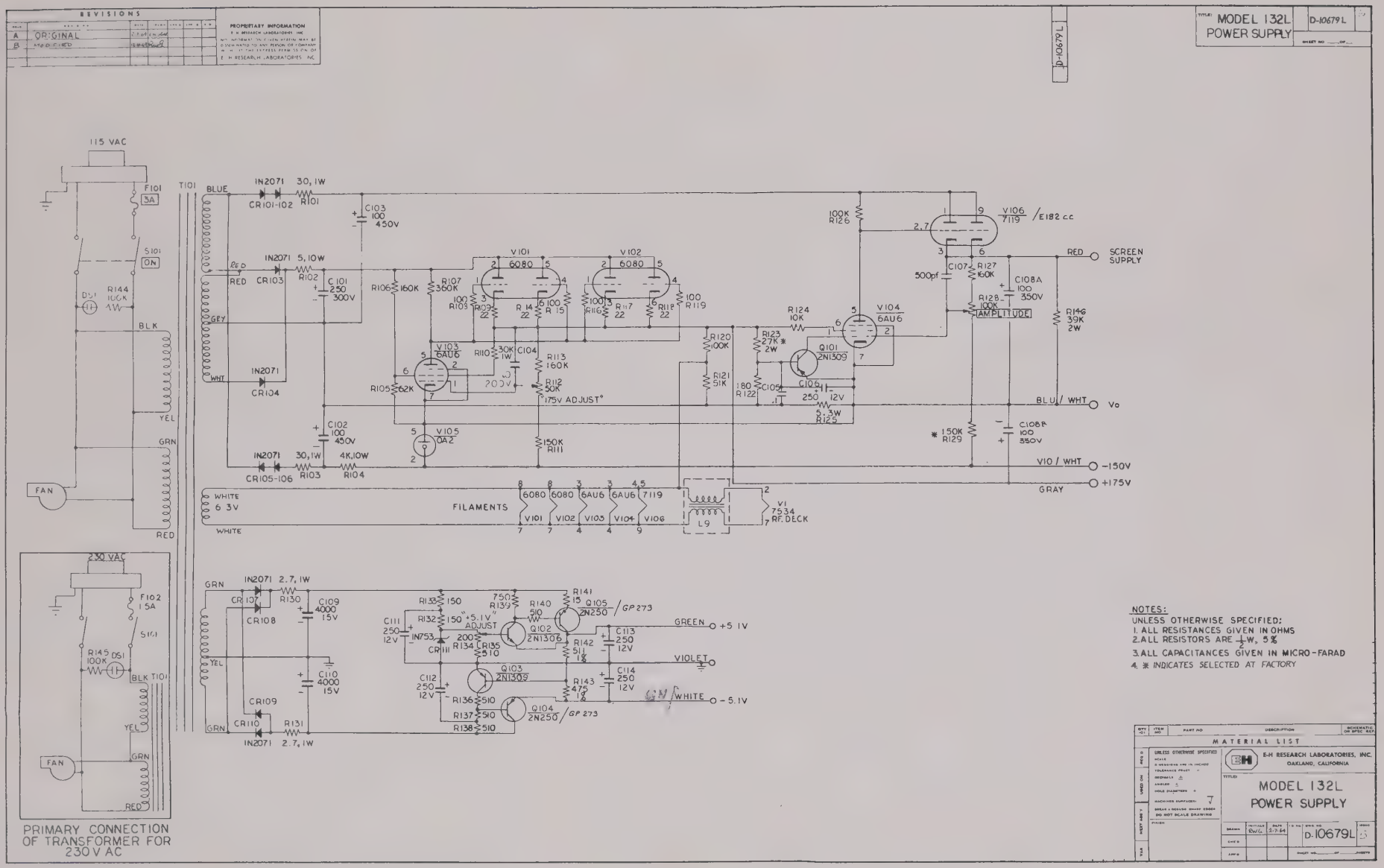
A pulse, coincident with the trigger output pulse, is coupled from the collector of Q5 via T3 to the double pulse gating diode CR31. When in the double pulse position the gating diode is forward biased and the coincident pulse is coupled to Q13 the start amplifier.
The output of Q13 drives the latch into its " on " position and starts the width multivibrator, which generates the stop pulse at the conclusion of its quasi-stable period. At a later time, determined by the period of the delay multivibrator, a second start pulse is delivered to Q13 and the sequence is repeated for the second pulse.

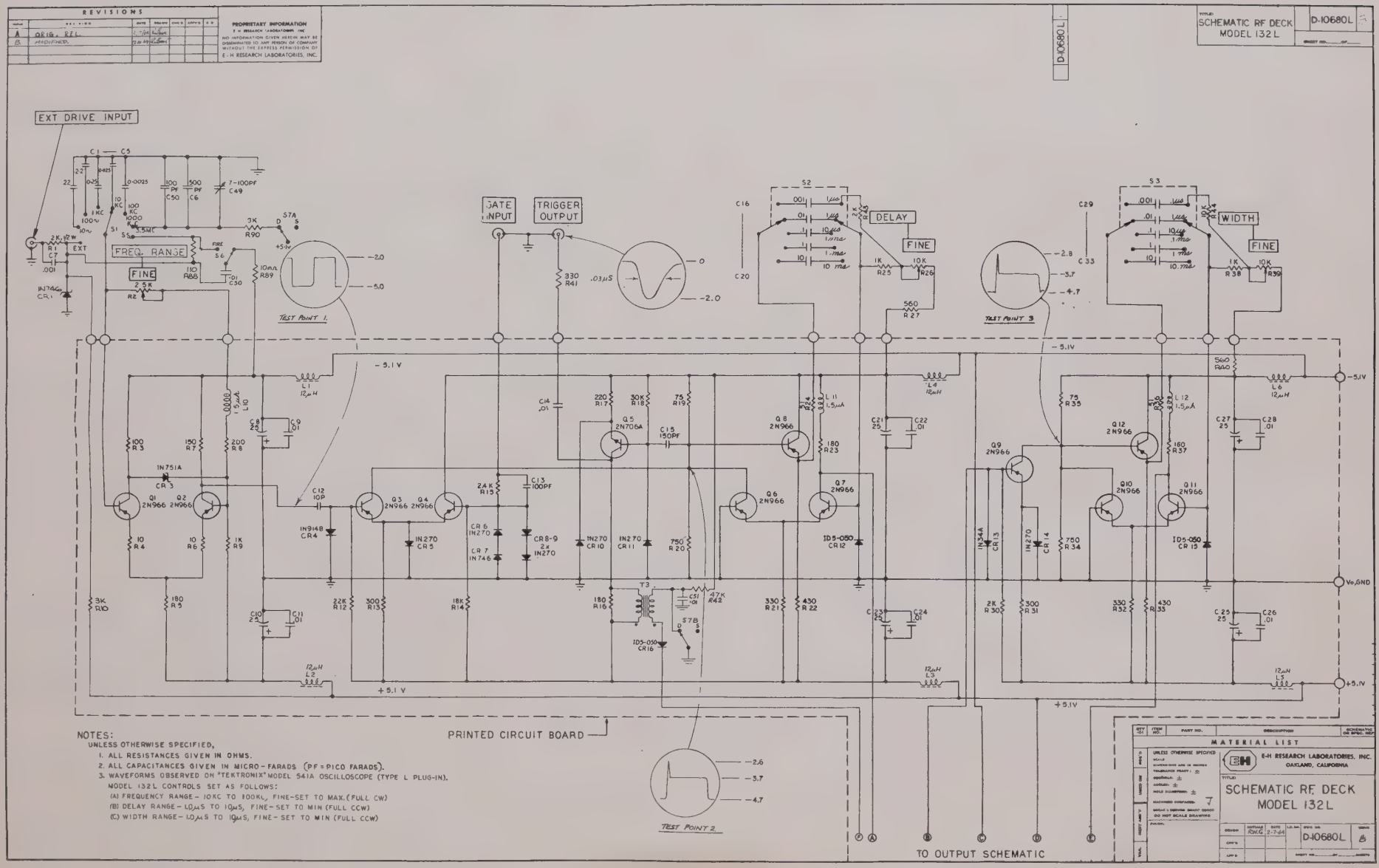
DUTY CYCLE LIMITING

The output pulse amplitude is controlled by the screen voltage of V1. At maximum amplitude, the screen is approximately 250 volts. Under this condition the cathode voltage is at maximum amplitude, about 50 volts, and the average current flowing is a function of the duty cycle. This current is monitored by R125 and averaged across capacitor C106 so that it appears as a voltage on the base of Q101. The collector of Q101 is connected directly to the grid of V104, which controls the grid voltage to V106. When this bias voltage reaches a point equivalent to 250 milliamps average current, Q101 conducts and pulls the screen of V106 down, thus reducing the screen supply and output amplitude proportionately.

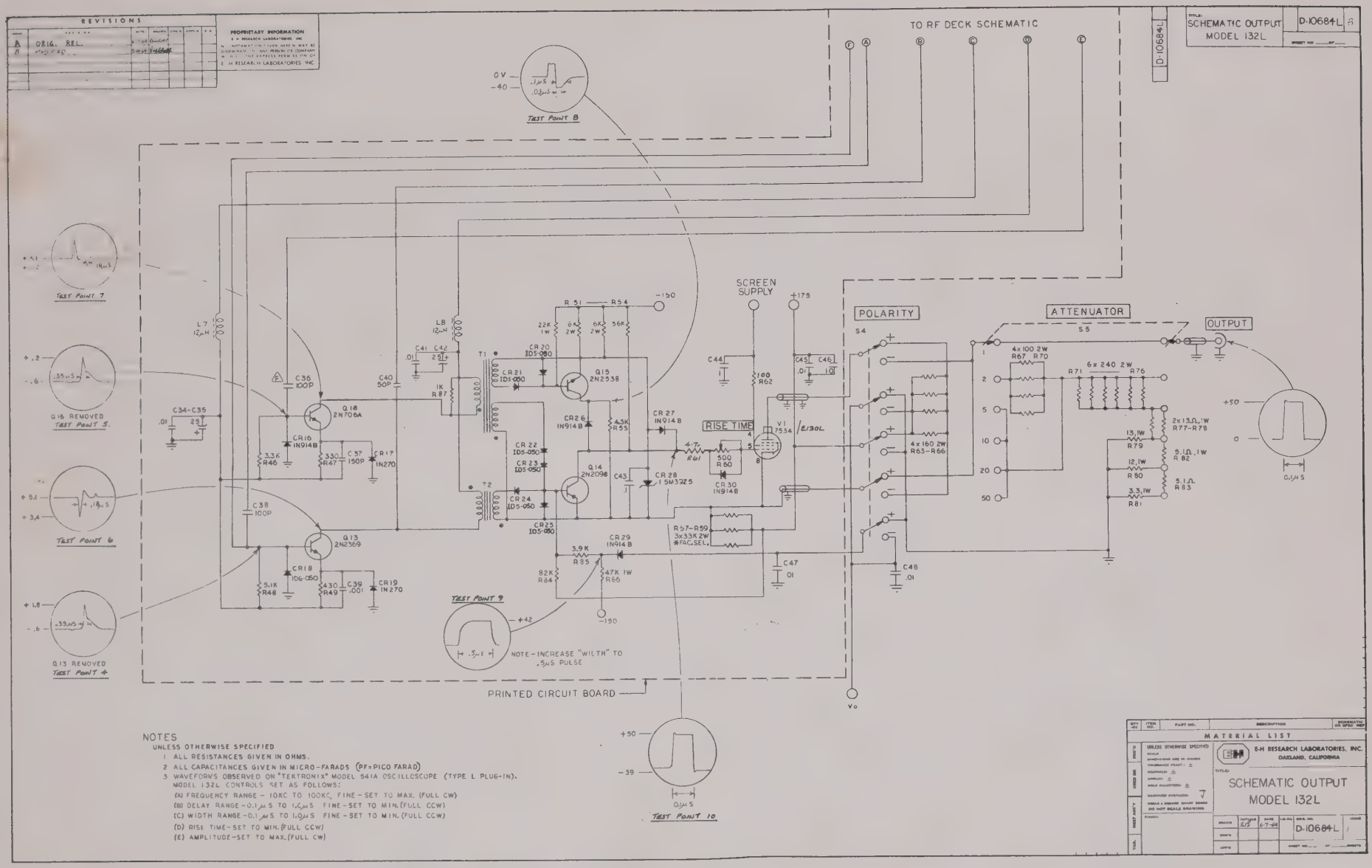
POWER SUPPLY

The +175 volt supply is a conventional series regulated supply and is referenced to the gas tube V105. V101 and V102 are the series regulators being controlled by V103. This +175 volts is set by adjusting the grid voltage of V103 with R112.
The +175 volt supply is floating so that both polarity output pulses may be obtained. For positive pulses. V_o is grounded; for negative output pulses, the +175 volts is placed at ground.
The —150 volt supply is shunt regulated by V105, an OA2. The +50 to +270 volt supply, which is the screen supply and output amplitude control, is regulated by the series tube V106 and the reference tube V104. This voltage is adjusted by R128 which is the front panel AMPLITUDE control. The screen supply also is floating so that both polarity output pulses may be obtained.
The low voltage timing circuit supply is controlled by two series transistors Q105 and Q104. Amplifiers Q102 and Q103 are referenced to the zener diode CR111.


REVISIONS
A ORIGINAL
B MODIFIED
PROPRIETARY INFORMATION
D-10679L
TITLE: MODEL 132L POWER SUPPLY
D-10679L
115 VAC
F101 3A
S101 ON
DS1
R144 100K 1W
BLK
YEL
GRN
RED
FAN
T101
BLUE
IN2071 30, 1W
CR101-102
R101
C103 100 450V
RED
IN2071 5, 10W
CR103
R102
C101 250 300V
GRY
WHT
IN2071
CR104
C102 100 450V
IN2071 30, 1W 4K, 10W
CR105-106
R103
R104
WHITE 6.3V
WHITE
FILAMENTS
V101 6080
V102 6080
V103 6AU6
V104 6AU6
V105 0A2
V106 7119
V1 7534 RF. DECK
L9
R106 160K
R107 360K
R108 100
R109 22
R 14 22
R 15 100
R116 100
R117 22
R118 22
R119 100
R110 30K 1W
C104
R113 160K
R112 50K "175V ADJUST"
200V
R105 62K
150K R111
R120 100K
R121 51K
R123 27K * 2W
R122 180
C105 .1
R124 10K
Q101 2N1309
C106 250 12V
5.3W R125
100K R126
2.7
C107 500pf
R127 150K
C108A 100 350V
R128 100K AMPLITUDE
R146 39K 2W
* 150K R129
C108B 100 350V
RED SCREEN SUPPLY
BLU / WHT Vo
V10 / WHT -150V
GRAY +175V
230 VAC
F102 1.5A
S101
R145 100K
DS1
BLK
YEL
GRN
RED
FAN
T101
PRIMARY CONNECTION OF TRANSFORMER FOR 230 V AC
GRN
IN2071 2.7, 1W
CR107
R130
C109 4000 15V
CR108
CR109
CR110
R131
IN2071 2.7, 1W
C110 4000 15V
R133 150
R139 750
R140 510
R141 15
Q105 2N250 / GP 273
GREEN +5.1V
R132 150 "+5.1V" ADJUST
200
R134
R135 510
Q102 2N1306
C111 250 12V
IN753
CR111
R142 511 1%
C113 250 12V
VIOLET
Q103 2N1305
C112 250 12V
R143 475 1%
C114 250 12V
GN/WHITE -5.1V
R136 510
R137 510
R138 510
Q104 2N250 / GP 273
NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTANCES GIVEN IN OHMS
2. ALL RESISTORS ARE 1/2 W, 5%
3. ALL CAPACITANCES GIVEN IN MICRO-FARAD
4. * INDICATES SELECTED AT FACTORY
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC. OAKLAND, CALIFORNIA
MODEL 132L POWER SUPPLY
D-10679L



NOTES:
UNLESS OTHERWISE SPECIFIED,
1. ALL RESISTANCES GIVEN IN OHMS.
2. ALL CAPACITANCES GIVEN IN MICRO-FARADS (PF = PICO FARADS).
3. WAVEFORMS OBSERVED ON "TEKTRONIX" MODEL 541A OSCILLOSCOPE (TYPE L PLUG-IN).
MODEL 132L CONTROLS SET AS FOLLOWS:
(A) FREQUENCY RANGE - 10KC TO 100KC, FINE-SET TO MAX. (FULL CW)
(B) DELAY RANGE - 1.0 μS TO 10 μS, FINE - SET TO MIN (FULL CCW)
(C) WIDTH RANGE - 1.0 μS TO 10 μS, FINE - SET TO MIN (FULL CCW)


REVISIONS
A 0816. REL.
PROPRIETARY INFORMATION
TO RF DECK SCHEMATIC
TEST POINT 8
TEST POINT 7
TEST POINT 5
TEST POINT 6
TEST POINT 4
TEST POINT 9
TEST POINT 10
SCREEN SUPPLY
+175
-150
POLARITY
ATTENUATOR
OUTPUT
S4
S5
RISE TIME
Y1 7534 E/30L
Q18 2N706A
Q16 2N2538
Q14 2N2098
Q13 2N2369
T1
T2
L7 12μH
L8 12μH
C36 100P
C38 100P
C40 50P
C34-C35 29
C41 C42 25
C43
C44
C45 C46 .01 .1
C47 .01
C48 .01
R62 100
R61 4.7
R60 500
R87 1K
R55 4.3K
R54 56K
R51 6K 2W
R85 3.9K
R84 82K
R66 47K 1W
R57-R59 3x33K 2W *FAC.SEL.
R67 R70 4x100 2W
R71 R76 6x240 2W
R63-R66 4x160 2W
R77-R78 2x13Ω 1W
R79 13 1W
R82 5.1Ω 1W
R80 12 1W
R83 5.1Ω
R81 3.3 1W
CR20 CR21 CR22 CR23 CR24 CR25 IDS-050
CR26 CR27 CR28 CR29 1N914B
CR16 CR17 CR18 CR19 1N270
PRINTED CIRCUIT BOARD
NOTE-INCREASE "WILTH" TO .5μS PULSE
NOTES
UNLESS OTHERWISE SPECIFIED
1 ALL RESISTANCES GIVEN IN OHMS.
2 ALL CAPACITANCES GIVEN IN MICRO-FARADS (PF=PICO FARAD)
3 WAVEFORMS OBSERVED ON "TEKTRONIX" MODEL 541A OSCILLOSCOPE (TYPE L PLUG-IN).
MODEL 132L CONTROLS SET AS FOLLOWS:
(A) FREQUENCY RANGE - 10KC TO 100KC, FINE - SET TO MAX. (FULL CW)
(B) DELAY RANGE - 0.1 μS TO 1.6μS FINE - SET TO MIN. (FULL CCW)
(C) WIDTH RANGE - 0.1 μS TO 1.0μS FINE - SET TO MIN. (FULL CCW)
(D) RISE TIME - SET TO MIN. (FULL CCW)
(E) AMPLITUDE - SET TO MAX. (FULL CW)
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
SCHEMATIC OUTPUT
MODEL 132L
D-10684-L

MAINTENANCE & CALIBRATION

COMPONENTS

Premier quality components and carefully controlled manufacturing methods have been used in this instrument to ensure long life with a minimum of maintenance.

It is recommended that all replacement valves, diodes and transistors be obtained from the manufacturer. Special attention is called to the factory selected components V1 and Q14. These elements are vital to the performance of the instrument with regard to pulse shape and amplitude and should be replaced only by factory supplied units.

TEST EQUIPMENT

The following test equipment will be required for verification of the 132L performance.

1. A fast rise time oscilloscope having passband sufficient for accurate observation of 10 nanosecond pulses. A 4 nanosecond scope, equivalent to a passband of 85 megacycles, will add approximately 0.8 nanoseconds to the 10 nanoseconds switching times of the 132L. This is adequate for normal maintenance work.
2. A general purpose oscilloscope of 25 megacycles passband, with high impedance low capacity probe and d.c. input capability down to 0.5 volt per centimetre.
3. A pulse generator having repetition rates to 3.5 megacycles, variable width up to several milliseconds, and variable output of at least 5 volts into low impedance loads.
4. An accurate multimeter.
5. A 50 ohm load having no more than 1% deviation from nominal resistance, capable of dissipating 15 watts, with good RF characteristics to 100 megacycles.

PERFORMANCE CHECK

A complete performance check may be made as follows:

1. **Repetition rate**
   Observe single output pulse on time calibrated oscilloscope. For each position of the FREQUENCY decade switch check repetition rate at extremes of the FINE control. There should be at least 5% overlap between ranges, with smooth and continuous variation, provided by the vernier.
2. **Delay**
   If a dual trace oscilloscope is available the delay ranges may be easily measured as the time difference between trigger pulse and output pulse leading edge. On all except the lowest delay range of 0.1 to 1 μs a satisfactory measurement may be made by triggering externally, observing the position of the trigger pulse on the sweep, and using this point as a time zero in observing the output pulse. The single trace technique is subject to suspicion at 0.1 μs because of the possibility of shift in the oscilloscope trigger point with the change in observed waveform. Note that the repetition rate must be decreased as delay is advanced, to ensure that the delay is no more than half of the period. Spurious and erratic pulsing will occur for delays much in excess of 50% of the period.
3. **Width**
   Observe single output pulse at full amplitude. Measurement is made at 50% of pulse height. Frequency should be decreased as width is advanced.
4. **Output**
   a. Measure amplitude of negative pulse into 50 ohms at reduced duty cycle. It should be at least 50 volts. Check positive pulse amplitude.
   b. At 1 μs pulse width and 50 volt amplitude, increase duty cycle to 25% by increasing repetition rate. Amplitude should remain nearly constant to 25%, then decrease as a function of repetition rate as the overload limiter takes control at 25% to 27%. This limiter is designed to hold average output current to 250 ma.
   c. Measure rise time at 50 volts, both polarities. The rise time control should vary the time between 10% and 90% points from less than 12 nanoseconds to more than 100 nanoseconds. At minimum rise time overshoot should be less than 5%, with pulse top aberration approximately 2%.
   Caution: Wide band oscilloscopes are prone to overshoot and ringing. The characteristics of load and display system may affect the observed waveforms by large percentages.

d. Check all attenuator positions. Amplitude ratios should be within 10% of nominal.

AUXILIARY FUNCTIONS

a. Check that the DOUBLE PULSE pushbutton will produce a pre-pulse whose position relative to the main pulse is variable by the DELAY control. The pre-pulse should be inhibited on the highest repetition range, i.e., 1 to 3.5 megacycles.

b. Check operation of the FIRE pushbutton on the SINGLE SHOT position of the FREQUENCY control.

c. Check external drive using a negative input from another pulse generator. The 132L should drive to 3.5 megacycles with 4 volt or less negative-going input. Note that the frequency vernier will control drive threshold.

d. Check gating action with a —5 volt 1 millisecond pulse input.
Pulse bursts should be clean with no latch hang-up or spurious effects.

e. Check trigger output for approximately —2 volts into high impedance load (double pulse mode), or 4 volts in single pulse mode, 25 to 50 nanoseconds in width.

SERVICING

Thorough familiarity with the functional block diagram (Fig. 1) is necessary for intelligent servicing of the instrument. On the schematic diagrams will be found typical waveforms associated with test points identified by number. The test points with their appropriate number will also be found on the printed circuit boards. A few minutes spent in learning the layout and the significance of the waveforms illustrated will help you to trouble-shoot a fault efficiently.

A suggested routine in correcting faults is as follows:

1. Be sure that normal supply voltages are present:

   a. Check ± 5.1 volt supplies. Note that these supplies are symmetrically referenced to earth, and that the negative supply is referenced to the positive by a fixed network, while the positive is set by the trimpot R134, located on the rear circuit board. The positive rail should be set to 1% of the nominal value of 5.1 volts by R134; the negative rail should fall within 100 millivolts of this setting. Mains frequency ripple should be less than 15 millivolts peak-to-peak.

   b. Check the —150 volt rail. Note that this is referenced to V_o, which is at earth potential for positive pulse output only. Voltage tolerance ± 5%, ripple approximately 1 volt.

   c. Check the output valve anode supply (+ 175 volts) on positive pulse. This supply should be variable over a 30 to 40 volt range by R112 (H.T. ADJUST). Ripple should be less than 100 millivolts.

   This supply should be set for the least voltage which will allow specified voltage output on negative pulse, and will normally fall in the range 170/180 volts.

   d. Check the output valve screen supply on positive pulse. This supply is controlled by the front panel AMPLITUDE control over a range of approximately 100 to 245 volts. It should never exceed 250 volts. Ripple should be approximately 1 volt at 245 volts output.

2. From the symptoms and waveform checks determine the area or block of malfunction. Once the d.c. supplies are known to be functioning properly, a convenient break-down is between output circuitry and timing circuitry just as the schematic drawings are broken down. The timing circuitry is required to deliver only pairs of pulses in proper sequence to the output section, and a quick check of Test Points T6 (start pulse) and T7 (stop pulse) is sufficient to point the way back into the timing circuits if these points do not show correct waveforms, or into the latch and output stages if start and stop pulses are correct but the output is not.

3. Locate the defective component. Once the faulty circuit has been identified, usually by oscilloscope observation of input and output waveforms, careful measurement of d.c. levels with your oscilloscope will usually indicate a semi-conductor malfunction. You should note that several points in the circuitry are critical as to shunt capacitance and the oscilloscope loading will seriously affect the circuit. Example of this is the base of Q3 with signal coupled through 10 pF (C12). Oscilloscope observation here must be carried out at TP1 and TP2, and C12, CR4 and Q3 eliminated by d.c. measurement or by substitution. Throughout the timing circuitry, clamp diodes with series resistors to a supply are used to bias transistors (CR4 and R12, CR13 and R30 are typical). These may be checked easily using a d.c. voltmeter, remembering that the forward drop of germanium diodes (ID 5—050, 1N270) should be of the order of 300 to 500 millivolts, while the silicon 1N914B should be 600 to 800 millivolts. Germanium devices in general, like the high performance 2N966's used throughout, are more liable to defect than silicon, and should be suspected first. In 3 transistor complexes such as Q6, 7, 8, it is not easy to identify the faulty transistor. Simultaneous replacement of all three is often the quickest way to confirm component failure.

   To determine the cause of low output, be sure the load seen by the generator is 50 ohms on a short length of good cable of this impedance.

   Measure screen voltage of V1 on positive pulse at maximum amplitude. It should be at least 245 volts. Vary the anode supply (H.T. ADJUST) to be sure that space-charge limiting is not occurring. If all voltages are correct, remove V1 and observe the drive signal at its grid with expanded width. Base line should be approximately —39 volts, the nominal value of CR28, and the pulse drive should cause Q14 to saturate for 60 to 90 nanoseconds so that the grid waveform drives to near zero potential for this period. If this waveform is correct V1 is at fault and should be replaced.

PARTS LIST

ORDERING INFORMATION

To ensure your receiving the proper replacement part, please include the following information with your order.

1. Model Number and Serial Number of the instrument for which the replacement part is intended.
2. Circuit Reference of the part.
3. E-H Part Number.

Replacement parts may be ordered through your E-H Representative or from the factory

WARRANTY

This instrument is guaranteed to be free from defects in material and workmanship. Our obligation is limited to repairing the instrument should it prove to be defective, upon our examination, within one (1) year after the purchase date. Fuses and batteries are specifically excluded from warranty. Electron tubes, transistors, and diodes are warranted for six (6) months.

For In-Warranty repair of this instrument contact E-H Research Laboratories, Customer Service Department, and provide:

1. Instrument Model Number and Serial Number
2. Full details of the nature of the malfunction

Shipping instructions, or repair information and parts, will be given you promptly.

E-H RESEARCH LABORATORIES INC.
163 ADELINE STREET, OAKLAND, CAL. 94607 U.S.A.

E-H RESEARCH LABORATORIES A.G.
P.O. BOX 293, 6301 ZUG, SWITZERLAND
or 31 CAMDEN ROAD, LONDON, N.W.1, ENGLAND TEL. GUL 4191

CIRCUIT REFERENCE	DESCRIPTION	E-H PART No.
C1	Capacitor, fixed, electrolytic, 22 uFd, 15 vwdc	316L001
C2	Capacitor, fixed, electrolytic, 2.2 uFd, 20 vwdc	316L002
C3	Capacitor, fixed metallized, Mylar, 0.25 uFd, 200 vwdc	320L001
C4	Capacitor, fixed, polystyrene, 0.025 uFd, 125 vwdc	326L001
C5	Capacitor, fixed, polystyrene, 2400 pF, 125 vwdc	326L002
C6	Capacitor, fixed, ceramic, 500 pF, 500 vwdc	311L001
C7	Capacitor, fixed, polystyrene, 1000 pF, 500 vwdc	326L003
C8	Capacitor, fixed, electrolytic, 25 uF, 25 vwdc	316L003
C9	Capacitor, fixed, ceramic 0.01 uF, 500 vwdc	311L002
C10	Same as C8	
C11	Same as C9	
C12	Capacitor, fixed, ceramic, 10 pF, 500 vwdc	311L003
C13	Capacitor, fixed, ceramic, 100 pF, 500 vwdc	311L004
C14	Same as C9	
C15	Capacitor, fixed, ceramic, 150 pF, 500 vwdc	311L005
C16	Capacitor, fixed, polystyrene, 1000 pF, 125 vwdc	326L004
C17	Capacitor, polystyrene, 0.01 uF, 500 vwdc	326L005
C18	Capacitor, metallized, Mylar, 0.1 uFd, 250 vwdc	320L002
C19	Capacitor, fixed, metallized, Mylar, 1.0 uFd, 250 vwdc	320L003
C20	Capacitor, fixed, electrolytic, 10 uF, 20 vwdc	316L004
C21	Same as C8	
C22	Same as C9	
C23	Same as C8	
C24	Same as C9	
C25	Same as C8	
C26	Same as C9	
C27	Same as C8	
C28	Same as C9	
C29	Same as C16	
C30	Same as C17	
C31	Same as C18	
C32	Same as C19	
C33	Same as C20	
C34	Same as C9	
C35	Same as C8	
C36	Same as C13	
C37	Same as C15	
C38	Same as C13	
C39	Capacitor, fixed, ceramic, 0.001 uFd, 500 vwdc	311L006
C40	Capacitor, fixed, ceramic 50 pF, 500 vwdc	311L007
C41	Same as C9	
C42	Same as C8	
C43	Capacitor, fixed, ceramic, 0.1 uFd, 200 vwdc	311L008
C44	Capacitor, fixed, ceramic, 0.1 uFd, 500 vwdc	311L009
C45	Same as C9	
C46	Same as C19	
C47	Same as C9	
C48	Same as C9	
C49	Capacitor, variable, 7-100 pF	332L001
C50	Same as C13	
C51	Same as C9	
C52	Same as C9	
C101	Capacitor, fixed, electrolytic 250 uF, 300 vwdc	316L005
C102	Capacitor, fixed, electrolytic, 100 uF, 450 vwdc	316L006
C103	Same as C102	
C104	Same as C19	
C105	Same as C43	
C106	Capacitor, fixed, electrolytic, 250 uF, 12 vwdc	316L007
C108A & B	Capacitor, fixed, electrolytic. 100 and 100 uFd, 350 vwdc	316L008
C109	Capacitor, fixed, electrolytic, 4000 uFd, 15 vwdc	316L009
C110	Same as C109	
C111-114	Same as C106	
CR1	Diode, Zener, 1N746A, 400 mW, 3.3 v, ±5%	374L001
CR3	Diode, Zener, 1N751A 400 mW, 5.1 v, ±5%	374L002
CR4	Diode, 1N914B	376L002
CR5-6	Diode, 1N270	376L003
CR7	Diode, same as CR1	
CR8-11	Diode, same as CR5	
CR12	Diode, AAZ13 or 1D5-050	376L001 376L006
CR13	Diode, 1N34A	376L004
CR14	Diode, same as CR5	
CR15	Diode, same as CR12	
CR16	Diode, same as CR4	
CR17	Diode, same as CR5	
CR18	Diode, same as CR12	

CIRCUIT REFERENCE	DESCRIPTION	E-H PART No.
CR19	Diode, same as CR5	
CR20-25	Diode, same as CR12	
CR26-27	Diode, same as CR4	
CR28	Diode, Zener, 1.5 w, 39 v, ±10%	374L003
CR29-30	Diode, same as CR4	
CR101-110	Diode, 1N2071	376L005
CR111	Diode, Zener, 1N753 400 mW, 6.2 v, ±10%	374L004
T1	Transformer, pulse	10660-01
T2	Transformer, pulse	10661-01
T3	Transformer, pulse	A10928L
T101	Transformer, power	653L016
L1-8	Inductor, 12 uH	335L001
L9	Inductor	10559-01
L10-12	Inductor, 1.5 uH	335L002
Q1-4	Transistor, 2N966	663L001
Q5	Transistor, 2N706B	663L002
Q6-12	Transistor, same as Q1	
Q13	Transistor, 2N2369	663L003
Q14	Transistor, 2N2098 (Selected)	663L004
Q15	Transistor, 2N2538	663L005
Q16	Transistor, same as Q5	
Q101	Transistor, 2N1309	663L006
Q102	Transistor, 2N1306	663L007
Q103	Transistor, same as Q101	
Q104-105	Transistor, 2N250	663L008
V1	Valve. 7534/E130L, pentode	670L001
V101-102	Valve, 6080, twin triode	670L002
V103-104	Valve, 6AU6, pentode	670L003
V105	Valve, 0A2/150C2, voltage regulator	670L004
V106	Valve, 7119/E182CC, twin triode	670L005
R2	Potentiometer, comp., lin. law, 2.5 K, 10%, 2 w	550L001
R26	Potentiometer, comp., lin. law, 10 K, 10%, 2 w	550L002
R39	Potentiometer, same as R26	
R51	Resistor, fixed, metal oxide, 22 K, 7% TE, 1 w	592L223
R52-53	Resistor, fixed, metal oxide, 16 K, 7% TE, 2 w	593L163
R57-59	Resistor, fixed, metal oxide, 33 K, 7% TE, 2 w (Factory selected)	593L333
R60	Potentiometer, comp., lin. law, 500 ohms, 30%, ½ w	550L003
R62	Resistor, fixed, composition, 110 ohms, ½ w	596L111
R63	Resistor, fixed, metal oxide, 240 ohms, 7% TE, 2 w × 6 = 40 ohms	593L161
R67	Resistor, fixed, metal oxide, 100 ohms, 7% TE, 2 w × 4 = 25 ohms	593L101
R71	Resistor, fixed, metal oxide, 240 ohms, 7% TE, 2 w × 6 = 40 ohms	593L241
R77-79	Resistor, fixed, metal oxide, 13 ohms, 7% TE, 1 w	592L130
R80	Resistor, fixed, metal oxide, 12 ohms, 7% TE, 1 w	592L120
R81	Resistor, fixed, metal oxide, 3.3 ohms, 5% 1 w	592L033
R82	Resistor, fixed, metal oxide, 5.1 ohms, 5% 1 w	592L051
R86	Resistor, fixed, metal oxide, 47 K, 7% TE, 1 w	592L473
R89	Resistor, fixed, composition, 10 M, 10%, ½ w	596L106
R101	Resistor, fixed, metal oxide, 30 ohms, 7% TE, 1 w	592L300
R102	Resistor, fixed, wire wound, 5 ohms, 5% 10 w	610L050
R103	Resistor, fixed, same as R101	
R104	Resistor, fixed, wire wound, 4 K, 5% 10 w	610L402
R110	Resistor, fixed, metal oxide, 30 K, 7% TE, 1 w	592L303
R112	Potentiometer, comp., lin, law, locking, 50 K, 10%, 2 w	545L001
R123	Resistor, fixed, metal oxide, 27 K, 7% TE, 2 w (Selected)	593L273
R125	Resistor, fixed, wire wound, 5 ohms, 5%, 3 w	610L050
R128	Potentiometer, comp., lin. law, 100 K, 10%, 2 w	550L004
R130-131	Resistor, fixed, metal oxide, 2.7 ohms, 5%, 1 w	592L027
R134	Potentiometer, multi-turn, lin, law, 200 ohms, 10%, 2 w	551L001
R142	Resistor, fixed, carbon film, 511 ohms, 1%, 1/8 w	595L511
R143	Resistor, fixed, carbon film, 475 ohms, 1%, 1/8 w	594L471
R146	Resistor, fixed, metal oxide, 38 K, 7% TE, 2 w	593L383

NOTE : All resistors on the schematic which are not shown on this list are ½ watt, ±7% TE, fixed, metal oxide.

	Connector, power, 3-pole chassis receptacle	700L001
	Fan blade, 4" counter-clockwise	493L001
	Fan motor	570L001
F101	Fuse, 3 amp. slo-blo	398L001
F102	Fuse, 1.5 amp., slo-blo	398L002

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